

Appl. No. 10/646,206

Preliminary Amdt. dated September 24, 2004

Amendments to the Specification:

Page 1, title:

~~ANTI-REFLECTIVE COATING (ARC) MATERIAL, SEMICONDUCTOR PRODUCT  
WITH AN ARC LAYER AND METHOD OF COATING A SEMICONDUCTOR  
PRODUCT WITH AN ARC LAYER~~

ANTI-REFLECTIVE COATING MATERIAL, SEMICONDUCTOR PRODUCT WITH  
AN ANTI-REFLECTIVE COATING LAYER AND METHOD OF COATING A  
SEMICONDUCTOR PRODUCT WITH AN ANTI-REFLECTIVE COATING LAYER

Page 1, lines 13-20:

Background of the Invention:Field of the Invention:

The invention lies in the semiconductor technology field and pertains, more particularly, to an anti-reflective coating ~~(ARC)~~ material for coating a semiconductor product. The anti-reflective coating material is made of a matrix substance and of nanocrystalline particles of another material than the matrix substance.

Page 2, lines 4-8:

The invention also refers to a semiconductor product comprising a substrate having a surface with a layer of an anti-reflective coating material on the surface and to a method of coating a semiconductor product with the ARC anti-reflective coating material.

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Page 3, lines 1-6:

Diminution of these deviations is achieved by first forming an anti-reflective coating layer, an ARC layer, before forming the resist layer. There are known ARC layers extinguishing reflections by destructive interference of light reflected at the upper and the lower surface of the ARC layer. Other ARC layers reduce reflection by absorption of incoming light.

Page 3, line 14, to page 4, line 6:

Summary of the Invention:

It is accordingly an object of the invention to provide an anti-reflective coating ~~(ARC)~~ for a semiconductor product and a semiconductor with an ~~ARC~~ anti-reflective coating layer which overcome the above-mentioned disadvantages of the heretofore-known devices and methods of this general type and which provides for a new kind of anti-reflective coating material for coating a semiconductor product or a layer on a semiconductor product to form an ~~ARC~~ anti-reflective coating layer, particularly an ~~ARC~~ anti-reflective coating layer of improved properties compared to prior art ~~ARC~~ anti-reflective coating layers.

With the foregoing and other objects in view there is provided, in accordance with the invention, a semiconductor processing method in which a semiconductor product is coated

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with an anti-reflective coating material formed of a matrix substance and of nanocrystalline particles of a material different from the matrix substance. The nanocrystalline particles absorb light via the quantum size effect. As a result, the ~~ARC~~ anti-reflective coating absorbs light energy.

Page 4, line 20, to page 5, line 10:

In other words, the objects of the invention are achieved with an anti-reflective coating in which the nanocrystalline particles absorb light via the quantum size effect. According to the invention, light absorption in the ~~ARC~~ anti-reflective coating layer is achieved by using the quantum size effect.

According to this effect, energy levels within the band gap of the ambient material, that is the matrix substance, are created. Electrons on both sides of the band gap may occupy these additional energy levels, thereby absorbing photons of the exposure light. By using this effect for light absorption in nanocrystalline particles of an ~~ARC~~ anti-reflective coating layer material, a new kind of ~~ARC~~ anti-reflective coating layer working primarily by absorption is provided.

Furthermore, as nanocrystalline particles are too small to cause wave reflections, disturbing reflected beams arising from the ~~ARC~~ anti-reflective coating layer material are suppressed.

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Page 6, line 7, to page 8, line 4:

According to a preferred embodiment, the matrix substance and the material and the concentration of the particles are chosen corresponding to a refractive index of the ARC anti-reflective coating material. These parameters are chosen such that a refractive index granting maximum light entrance into the ARC anti-reflective coating layer is achieved. Hence, maximum absorption within the ARC anti-reflective coating layer by means of the nanocrystalline particles is granted.

According to another embodiment, the material and the concentration of the particles are choosing corresponding to a degree of absorption. The degree of absorption may depend on the thickness of the ARC anti-reflective coating layer and, of course, on the wavelength to be absorbed.

According to another embodiment, the matrix substance and the size and the concentration of the particles are chosen corresponding to a viscosity value. An ARC anti-reflective coating layer is formed by coating a semiconductor product, especially a semiconductor wafer or flat panel, with an ARC layer precursor substance. The ARC anti-reflective coating layer precursor substance consists of the compounds of the ARC anti-reflective coating layer as well as the solvent allowing to spin on the ARC anti-reflective coating layer precursor

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substance onto a rotating semiconductor product. The amount of solvent in the ARC anti-reflective coating layer is adjusting its viscosity. When material is spun on, the temperature of the material itself is adjusted in order to optimise the spin process, the uniformity of the final layer on the substrate and the material consumption. The adjusted temperature is controlled during the whole spin process in order to guarantee the reliability of the procedure. The spin process is finished when the layer on the substrate has reached a stable condition in terms of drying. Right after the spin process at least one or more heating processes are applied in order to finalise the process of film creation. However, according to this embodiment, further the matrix substance and the size and the concentration of the particles are adjusted in addition with view to a viscosity value.

According to another embodiment, the matrix substance and the material and the concentration of the particles are chosen corresponding to an etch resistance of a dry etch process for etching semiconductor substrates. When a semiconductor product comprising an ARC anti-reflective coating layer and a resist layer above the ARC anti-reflective coating layer is etched, etching is proceeded in order to pattern the substrate of the ARC anti-reflective coating layer in the same way as the pattern mask itself. Precise shaping of three-dimensional

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structures requires a high etch resistance of the etching mask, that is the resist, and/or of the ARC anti-reflective coating layer. By carefully choosing the composition of the ARC anti-reflective coating layer, even this parameter may be controlled.

Page 8, lines 21-25:

Preferably, the ARC anti-reflective coating layer contains between 3 and 70 % per volume of nanocrystalline particles. The broad range of composition even with respect to the matrix to particle ratio contributes to a most flexible adjustment of the aforementioned parameters.

Page 9, lines 1-7:

According to an advanced embodiment of the invention, the ARC anti-reflective coating layer contains nanocrystalline particles of at least two different materials. Thereby, different ranges of wavelengths may be absorbed. By providing different kinds of particles, a predefined absorption profile may be shaped. Furthermore, fine adjustment of absorption profile may be achieved by choosing particles of a predefined average size.

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Page 10, lines 13-26:

Preferably the semiconductor product comprises a resist layer on top of the ARC anti-reflective coating layer, the resist layer preferably being made of an organic material.

When the kind and/or the concentration of the nano-crystalline particles are chosen to adjust such a refractive index of the anti-reflective coating material which depends on the refractive index of a resist layer to be applied onto the anti-reflective coating material, light reflection on top of the ARC anti-reflective coating material layer is reduced. Hence, at the intermediate surface between the resist layer and the ARC anti-reflective coating material layer, most part of incoming light is entering the ARC anti-reflective coating material layer material and is being absorbed by the nanocrystalline particles.

Page 11, lines 5-12:

Although the invention is illustrated and described herein as embodied in anti-reflective coating material, semiconductor product with an ARC anti-reflective coating layer and a method of coating a semiconductor product with an ARC anti-reflective coating layer, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from

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the spirit of the invention and within the scope and range of equivalents of the claims.

Page 12, line 5, to page 14, line 13:

Description of the Preferred Embodiments:

Referring now to the figures of the drawing in detail and first, particularly, to Fig. 1 thereof, there is shown an incoming light beam J entering the resist layer 5. The beam J is partially reflected at the intermediate surface or boundary between the resist layer and an ARC anti-reflective coating layer 2. This first reflected beam is denoted as R1. The remaining intensity enters the ARC anti-reflective coating layer 2 and is reflected at the intermediate surface or boundary 11 between the ARC anti-reflective coating layer 2 and the substrate 1. The resulting reflected beam R2 extinguishes the other beam R1 at least in part via destructive interference.

In the case of absorbing ARC anti-reflective coating layers, the refractive index of the ARC anti-reflective coating layer 2 is adjusted to be similar to the refractive index of the resist layer 5, thereby producing maximum transmission of the beam J into the layer 2 and absorbing the beam J within the ARC anti-reflective coating layer material. The present invention predominantly refers to the absorbing kind of ARC

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anti-reflective coating layers. It should be understood, however, that it applies also to destructive interference ARC anti-reflective coating layers as with a view to the three refractive indices of the resist 5, the ARC anti-reflective coating layer 2, and the substrate 1 an intensity variation of the reflected beam R2 may be useful. The reflected beam R1 is drawn in dashed lines as its intensity is rather low in case of absorbing ARC anti-reflective coating layers.

The prior art ARC anti-reflective coating layer material 2 illustrated in Fig. 1 is homogeneous. The ARC anti-reflective coating layer material 2 of the present invention illustrated in Fig. 2, on the other hand, comprises a matrix substance 3 embedding nanocrystalline particles 4 causing absorption of incoming light via the quantum size effect. Preferably two or more kinds of particles 4a, 4b are provided.

By exploiting this mechanism in the ARC anti-reflective coating layer 2, the reflected beam R2 is absorbed. The absorption profile can be shaped by providing different kinds or sizes of nanocrystalline particles, these and other composition parameters allowing an adjustment of further physical properties of the ARC anti-reflective coating layer itself.

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The production of the ARG anti-reflective coating layer material compounds progresses in a well-known manner. Nanocrystalline particles are extracted by chemical hydrolysis condensation; the matrix substance is produced by a sol gel process. According to the invention, the matrix substance and the nanocrystalline particles are mixed and other chemical substances like solvents or surface-active agents for better adhesion to the substrate are added. The ARG anti-reflective coating layer material composition is then spun onto the substrate and then heated up to a temperature not above 200°C in order not to crack polymer hydrocarbon chains of the matrix substance. During the heating, a certain amount of the solvent is removed and matrix substance molecules are interconnected with one another, thereby forming a network safely embedding the nanocrystalline particles.

Those of skill in the pertinent art will be able to choose the kinds and quantities of the matrix substance and of the nanocrystalline particles in order to appropriately tune physical properties such as refractive index, absorption profile, viscosity and etch resistance of the ARG anti-reflective coating layer.